

# Renewable Energy Group

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# Biodiesel 101

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# Biodiesel 101

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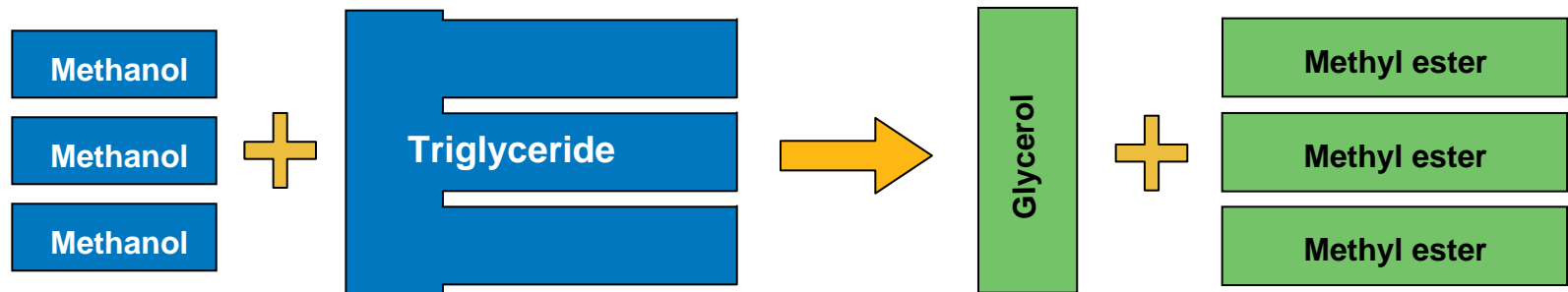
- Biodiesel basics
- Quality issues
- Blending considerations
- Recent EPA requirements



# Biodiesel basics

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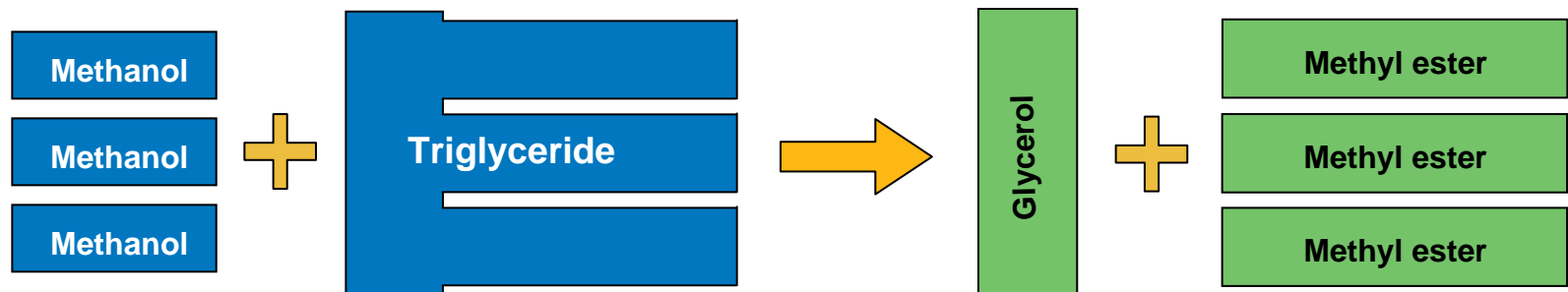
- Made from biological oils and fats (triglycerides) by a chemical process called transesterification
  - A refined manufactured product (methyl esters), not used fryer oil!



# Biodiesel basics

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- Made from biological oils and fats (triglycerides) by a chemical process called transesterification
  - A refined manufactured product (methyl esters), not used fryer oil!
- Produced to industrial specifications (ASTM D 6751)
- Used in modern diesel engines without modification in blends up to B100



# Advantages of biodiesel

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- Reduced Emissions
  - Sulfur, carbon monoxide, hydrocarbons, and particulates
  - Reductions increase with amount of biodiesel in blend
- Enhanced Lubricity
  - No lubricity additives needed with B2 or higher
  - Excellent for Ultra-Low Sulfur Diesel
- Positive energy balance
  - Efficiently produced from local feedstocks
  - ~3 BTU of energy produced for each BTU required
- Renewable and domestic energy source



# Safety and biodiesel

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- Biodegradable
  - Degrades as fast as sugar
  - Biodiesel blends accelerate biodegradability of petroleum diesel
- Non-toxic
  - Table salt (NaCl) is nearly 10 times more toxic
  - 24-hour human skin patch test results: Less irritation than 4% soap/water solution
- Non-hazardous
  - Comparable to vegetable oil
  - Increases fuel conductivity—particularly important for ULSD

# Biodiesel quality

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- ASTM D 6751 provides biodiesel specifications
  - 17 different tests (currently)
  - Includes water and sediment, viscosity, and purity indicators
- Certificate of Analysis
  - Lists specifications and results
  - All biodiesel should come with a “C of A”



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- Certificate of Analysis
  - Lists specifications and results
  - All biodiesel should come with a “C of A”
- BQ-9000: Accredited Producers & Certified Marketers
  - Rigorous, externally-monitored quality programs
  - Accredited Producers: no “off spec” biodiesel leaves the plant
  - Certified Marketers: no “off spec” biodiesel is sold

# ASTM D 6751 specifications

Flash Point / Methanol	ASTM D93	130 min °C
Water & Sediment	ASTM D2709	0.050 max % vol.
Kinematic Viscosity 40 C	ASTM D445	1.9 – 6.0 mm <sup>2</sup> /sec
Sulfated Ash	ASTM D874	0.020 max % mass
Sulfur	ASTM D5453	Depends on S grade
Copper Strip Corrosion	ASTM D130	No. 3 max
Cetane	ASTM D613	47 min
Cloud Point	ASTM D2500	Report °C (depends on feedstock)
Carbon Residue 100% sample	ASTM D4530	0.050 max % mass
Acid Number	ASTM D664	0.50 max mg KOH/gm
Free Glycerin	ASTM D6584	0.020 max % mass
Total Glycerin	ASTM D6584	0.240 max % mass
Phosphorous Content	ASTM D4951	0.001 max % mass
AET 90% Recovered	ASTM D1160	360 max °C
Oxidative Stability	EN 14112	3.0 hr (minimum)
Na and K, combined	EN 14538	5.0 max ppm
Ca and Mg, combined	EN 14538	5.0 max ppm

# Feedstock notes

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- Biodiesel methyl esters can be made from many feedstocks
  - Vegetable oils (soy, rapeseed [canola], palm)
  - Animal fats (pork CWG, beef tallow)
  - Used oils (yellow and brown grease)
- Production skill, not feedstock, determines fuel quality
- Feedstock determines some physical properties
  - Cloud point / pour point
  - Oxidative stability
  - Iodine value (IV)

# Blending biodiesel

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- Issues to consider:
  - Blending technique (splash or inline, temperature)
  - Handling and storage
- Federal blender's tax credit: \$1 per gallon B100 blended
- How much biodiesel?
  - B2, B5, B11, and B20 are common (also B99.9)
  - Blend choice depends on
    - price
    - usage rate
    - mandates or additional tax incentives
    - seasonal temperatures and triglyceride feedstock



# Disadvantages of biodiesel

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- Nobody's perfect...



# Disadvantages of biodiesel

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- Nobody's perfect...
- Additional care required
  - Moisture (microbes, sediment)
  - Oxygen (stability)
  - Temperature (viscosity, stability)
  - Tank bottoms management (water, microbes, sediment)

# Disadvantages of biodiesel

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- Nobody's perfect...
- Additional care required
  - Moisture
  - Oxygen
  - Temperature
  - Tank bottoms management
- Slightly lower energy density (1-2% for B20)
- Solvent properties: elastomers, tank residues, fuel filters
- Dedicated tank with heel and bottom drain recommended

# OEM warranties

- All major OEMs currently support at least B5
  - Biodiesel in blend must meet ASTM D 6751
  - A growing number recommend the use of biodiesel from BQ-9000 companies

Manufacturer	Position
Engine Manufacturers Association (EMA)	B5 acceptable if it meets D 6751.
Caterpillar	Many engines approved for B100; for others only B5 is acceptable. Must meet D 6751.
Cummins	All engines approved for B5; must meet D 6751.
DaimlerChrysler	B5 acceptable for all vehicles, but must meet D 6751.
Detroit Diesel	B20 approved for all engines/vehicles, but must meet DDC specific diesel fuel specification.
Ford	B5 acceptable for all vehicles, but must meet both D 6751 <i>and</i> EN 14214.
General Motors	B5 acceptable for all vehicles, but must meet D 6751.
International Truck and Engine	B20 acceptable for all engines, but must meet D 6751.
John Deere	B5 acceptable for all engines, but must meet D 6751.
Volkswagen	B5 acceptable for all engines, but must meet fuel quality standards (D 6751 or EN 14214).
Fuel Injection Equipment Manufacturer	Position
Bosch	B5 acceptable for all vehicles, but must meet EN 14214.
Delphi	B5 acceptable for all vehicles, but must meet D 6751.
Stanadyne	B20 acceptable for all vehicles, but must meet D 6751.

Source: IFEC Biodiesel Center. See also: MBP Fuel Quality Standards & Information available at



# EPA requirements

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- New diesel vehicles must have diesel particulate filters
  - Biodiesel can enhance engine performance with a DPF and improve DPF performance and longevity

# EPA requirements

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- New diesel vehicles must have diesel particulate filters
  - Biodiesel can enhance engine performance with a DPF and improve catalyzed DPF performance and longevity
- 80% of on-road diesel fuel must be ULSD (<15 ppm)
  - Biodiesel is an ultra-low sulfur blending stock, conductivity aid, and lubricity enhancer
  - Aside: more sulfur in off-road fuel & heating oil (up to 5000 ppm)
- ASTM D 6079 lubricity requirement effective Jan 1, 2005 for diesel fuels
  - Sulfur compounds are the intrinsic lubricants in diesel

# Biodiesel adds significant lubricity to ULSD

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Diesel type	Biodiesel amount	Wear scar size (microns)	% Improvement
#2 ULSD	none	580	52%
	B2	280	
#1 ULSD	none	680	44%
	B2	380	

- Results for ASTM D 6079 (HFRR lubricity test)
- Maximum acceptable value = 520 microns

# Biodiesel benefits summary

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- Inherently compatible with compression engines, diesel fuel, and existing fuel infrastructure
- Reduces harmful emissions (heating oil)
- Greatly enhances lubricity, particularly with ULSD
- Improves ULSD conductivity
- Similar engine power output
- Improves performance of DPFs and diesel exhaust catalysts
- Renewable, non-toxic, and “green” blend stock option
- Promotes national energy security



# Information sources

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- *National Renewable Energy Lab (Dep't of Energy)*
  - DOE's "Biodiesel Handling and Use Guidelines" available at [www.osti.gov/bridge](http://www.osti.gov/bridge) (or call 865-576-8401 to order a paper copy)
- *National Biodiesel Board*

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Thank you!

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# Cummins: fuel filter plugging analysis

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- Testing
  - Samples sent to them by customers
  - Customers complain of filter plugging problems
- Testing concludes causes of filter plugging:
  - Asphaltene precipitation
  - Biological organisms
  - Engine lube oil mixed with fuel
  - Solid Particles (dirt)





# Asphaltene

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- The material is similar to asphalt
- Forms in engines with elevated temps and high return fuel flow
- Polymerization and growth of long chain molecules
- Usually injected and burned before polymerization in engines with lower rates of fuel return



# Engine oil

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- Elements in engine oil sometimes present on plugged fuel filters
- If engine or lube oil is dumped into fuel tank, it does not dissolve
  - It falls to the bottom or stratifies into density layers in the tank
- Aluminum and oxygen are also sometimes found
  - Resulting from the alumina catalyst used in the petroleum cracking process.

# Biological Organisms

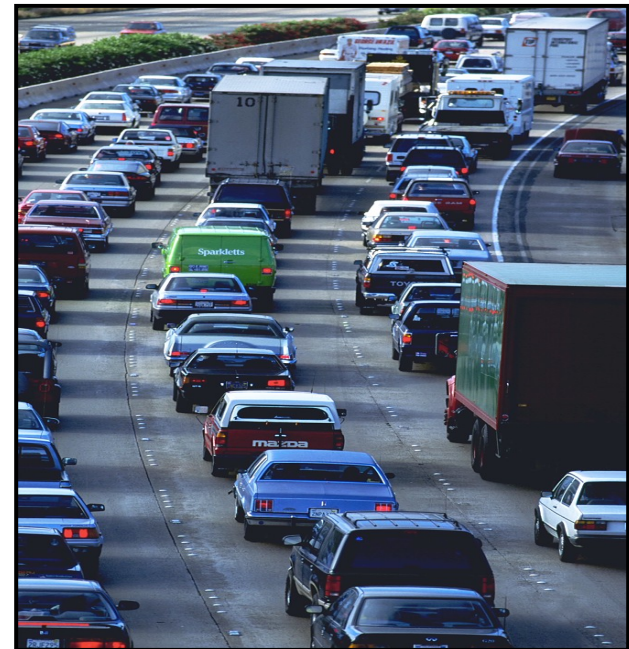
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- Biological organisms are large enough to coat any filter media
  - Such as 140 micron screen pre-filters
  - Shiny black layer of material often visible on a filter with microbiological contamination
  - Sometimes a microscope is necessary to see the outer layer of biological organisms
- Microbes need water to grow, whether on biodiesel or petrodiesel

# EPA requirements

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- EPA regulations require reduced sulfur in diesel fuel
  - 80% of highway diesel fuel must be ULSD (<15ppm sulfur)
  - Biodiesel is an ULS blending stock and lubricity enhancer
- As of January 1, 2007, every new vehicle must have a diesel particulate filter (DPF)
  - Catalyzed DPFs can eliminate 99% of solid particles and more than 90% of hydrocarbons
  - Biodiesel can enhance engine performance with a DPF



# Diesel Particulate Filters (DPF)

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- Effect of biodiesel blends on DPFs studied by the National Renewable Energy Laboratory (NREL)
- B20 lowered balance point temperature by 45 °C
  - may increase fuel economy with DPF
  - reduces initial burden on DPF and increases DPF life
- Also reduces engine oil soot levels and enhances exhaust gas recirculation (EGR) performance

